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A Long-run Version of the Bank of Canada Commodity Price Index, 1870 to 2015

by Ryan Macdonald

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^{r} revised
x suppressed to meet the confidentiality requirements of the *Statistics Act*
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F too unreliable to be published
* significantly different from reference category ($p < 0.05$)

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Statistics Canada

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Abstract

This paper develops historical estimates of the Bank of Canada commodity price index (BCPI) and links them to modern estimates. Using a collection of historical data sources, it estimates weights and prices sufficiently consistently to merit the construction of long-run estimates that may be linked to the modern Fisher BCPI. The resulting long-run Fisher BCPI estimates show a repeated pattern of rapidly changing prices followed by periods of calm. This pattern is most pronounced since 1900.

Keywords: commodities, super cycles, price index

Executive summary

Canada is a trading nation that produces significant quantities of resource outputs. Consequently, the behaviour of resource prices that are important for Canada is germane to understanding the progress of real income growth and the prosperity of the country and the provinces. Demand and supply shocks or changes in monetary policy in international markets may exert significant influence on resource prices, and their fluctuations constitute an important avenue for the transmission of external shocks into the domestic economy.

The Bank of Canada commodity price index (BCPI) is used to analyze and better understand these types of links between global commodity markets and important macroeconomic variables and phenomena, such as inflation, the U.S.–Canada exchange rate, the allocation of resources in production, regional growth patterns, and real income growth from the terms-of-trade changes. Currently, the BCPI extends from 1972 to the present. It includes a range of commodities important for Canada and the provinces. But, given its relatively short time span, it cannot be used to examine the long-run effects of commodity prices or how current commodity cycles relate to previous ones.

Drawing on a collection of historical data, this paper fills these information gaps by providing estimates of production weights and prices suitable for creating a historical BCPI. Fisher chain indexes based on the historical data are calculated and linked to the BCPI to create a long-run narrative of the movements of commodity prices important for production in Canada that spans from 1870 to the present.

While historical values for the BCPI and its sub-indexes can be created using historical data, it is important to note that the methods employed create estimates. This occurs because the process of constructing the historical estimates relies on data sources that are not as coherent as modern data sources nor were the data collected for the purpose to which they are put in this paper. Although the historical estimates contain appropriate historical information for economic analysis, they may not be as representative as current estimates.

The historical calculations show a number of historical events, from the emergence of oil production to the electrification of the production process. Therefore, they contain information relevant for understanding processes related to emerging commodity production and structural change. They also contain significant information about the timing of pressure exerted by commodity prices on Canada. And, through time, they show a process in which a number of waves of price increase apply pressure for short periods of time, followed by periods of calm. This pattern is most pronounced since 1900.

1 Introduction

Canada is a trading nation that has a comparative advantage in the production of commodities (Coletti 1992). Consequently, the behaviour of resource prices that are important for Canada is germane to understanding the progress of the U.S.–Canada exchange rate (Cayen et al. 2010; Maier and DePratto 2008; Issa, Lafrance and Murray 2008; Bailliu and King 2005; Powell 2005; Amano and van Norden 1993), of real income growth (Brown and Macdonald 2015; Baldwin and Macdonald 2012; Macdonald 2010, 2008, 2007; Duguay 2006; Kohli 2006; Francis 2008; Coletti 1992), of prices for intermediate inputs into the production system (Hirsch 2003), and of inflation (Kolet and Macdonald 2010; Cheung 2009). Because commodities are traded on global markets, demand and supply shocks in these markets can exert significant influence on the allocation of production across industries and regions within Canada. The fluctuations of commodity prices constitute an important avenue for the transmission of external shocks into the domestic economy.

Currently, the Bank of Canada commodity price index (BCPI) extends from 1972 to the present. It includes a range of commodities whose production is important for Canada and the provinces (Kolet and Macdonald 2010). The commodities cover the major agricultural, mineral, energy, forestry and fisheries outputs from the Canadian economy. These outputs are, subsequently, important inputs into upstream production within the Canadian economy. They are also important as exports to world markets that facilitate the purchase of machinery and equipment and consumer goods or that finance repayment of debts to external creditors. However, given the relatively short time span of the index, it is of limited use for understanding long-run relationships between commodity prices and variables of interest, such as inflation or the exchange rate, or for facilitating econometric estimation of the parameters of these relationships. It is also of limited use for examining how current commodity cycles relate to previous ones.

This paper aims to fill this information gap by providing historical BCPI estimates that may be used for this type of inquiry. Estimates of production weights and prices suitable for linking with the BCPI are created by drawing on a collection of historical data. Fisher chain indexes based on the historical data are calculated and linked to the BCPI to create a narrative of the movements of commodity prices important for the Canadian economy that spans from 1870 to the present.

Because the goal is to extend the BCPI, only those commodities currently in the BCPI are included in the historical calculations. These commodities include major agricultural outputs, major mineral products, major forestry products, major energy products and fisheries products. Owing to the breadth of commodities in the BCPI, the decision to maintain the current commodity bundle over historical periods does not cause significant measurement issues. This is because over most of the history of Canada, the same types of products are important for production and for export, but their relative importance changes (Baldwin and Macdonald 2012). Consequently, applying a chain-index formula allows the weights for the index to be continuously updated, and this makes the index relevant for the entirety of the period from 1870 to the present.

Nevertheless, it is important to note that the further one goes into the past, the less representative the index is likely to be. This is the case because the BCPI mixes Canadian production values with global prices for commodities that are measured in U.S. dollars. At present, it can be argued that the U.S. price represents the world price and, thus, the price reflecting supply and demand conditions on global markets that affect Canadian producers.[1] However, for earlier periods, this may not be the case. In particular, prior to the Second World War, prices quoted in British pounds may be equally or more representative of world prices. Consequently, it is not clear a priori that

1. The BCPI reflects foreign demand and supply conditions faced by Canadian producers. It is, therefore, suitable for analysis that aims to understand the influence of the rest of the world on Canada and transmission mechanisms from the rest of the world to Canada. It does not provide information about Canadian input markets, industrial structures or technological choices.

continued use of U.S. prices is appropriate for gauging the effect of changes in global commodity markets on the Canadian economy. Moreover, in the period between 1870 and the First World War, an important convergence in commodities between the Old World and the New World occurred (O'rourke and Williamson 1994). This convergence raised the price of commodities in the United States relative to the United Kingdom. Therefore, it is expected that different price pressures could be found by using U.K. prices rather than U.S. prices during the early part of the sample period.

Here, the assumption is made that prices in U.S. dollars are sufficiently representative of the price changes relevant to Canadian producers in global commodity markets that they may be used to calculate historical index values. This assumption is derived from the fact that the convergence between New World and Old World prices stemmed from dramatic changes in transportation costs. As a result, the same type of convergent forces should be present for both the Canadian economy and the U.S. economy with respect to Europe. The applicability of this assumption is borne out in the results section below, which shows that historical BCPI estimates are consistent with other data sources.

The remainder of this paper is structured as follows. Section 2 describes the data sources used, while Section 3 describes the methodology. Section 4 describes the results both in terms of the production shares and the chained indexes themselves. Section 5 concludes the paper.

2 Data

The data collected here, which are used to compile estimates of the historical BCPI, are drawn from a variety of sources with different methodologies. Great effort has been made to find source data that are consistent through time and that are consistent with the composition of the underlying commodities.

In the subsections that follow, the source data for values and prices across the commodities used to calculate the historical BCPI are discussed. The discussion follows the major groups for which commodity data are collected: energy, metals and minerals, forestry, agriculture, and fisheries. The data are grouped in this fashion to match the structure of the BCPI and its sub-aggregate indexes, and because the source of historical data is often the same for similar types of commodities. In the discussion, the span of data differs from that in the tables. The data discussions indicate the full span of the data available while the tables indicate only the data employed in the index. Differences can occur, for example, because estimates for the value of production extend farther into the past than do the price series, or vice versa.

2.1 Energy

Data for historical energy prices are drawn from two sources (Table 1). Estimates of the U.S. price of oil are taken from the U.S. Energy Information Administration's (EIA) U.S. Crude Oil First Purchase Price (EIA 2017), measured in U.S. dollars per barrel. The EIA provides a time series spanning 1870 to 1972. For coal and natural gas, prices are taken from Manthy (1978). The coal price corresponds to U.S. dollars per ton of anthracite. The natural gas price is in U.S. cents per million cubic feet. The coal and natural gas prices cover the 1870-to-1972 and 1919-to-1972 periods, respectively.

Data on production values for energy are drawn from two sources. Production values from 1961 to 1972 are taken from the input–output series used in the currently published BCPI (Kolet and Macdonald 2010). Historical production values are taken from the *Historical Statistics of Canada* (Statistics Canada n.d.*a*) for the three energy commodities.

Values for coal extend from 1870 to 1961. Values for 1871 to 1873 are estimated based on interpolated estimates of the price per ton of coal from Series Q1-5 of *Historical Statistics of Canada* multiplied by the tons of production from Series Q6-12 (Quirin n.d.*a*). The interpolation is applied either because of missing data points or because of unexplained outliers in Series Q6–12 in the years 1871, 1872 and 1873. In addition, the value for coal production in 1945 contains a typo. The average of 1944 and 1946 is used in its place.

Values for natural gas span 1892 to 1962, while values for crude oil span 1870 to 1962. Oil production values from the *Historical Statistics of Canada* (Quirin, n.d.*b*) span 1886 to 1962. For the years 1870 to 1885, the volume of production (thousands of barrels per day) is multiplied by the price per barrel from the EIA to create a nominal dollar projector series. The growth rate of this series is then used as a basis to back-cast the historical growth rates for the value of production. However, unlike other series where the projector is taken "as is," the variance of the projector series for oil is larger than the variance of the production series. As a result, a regression is used to predict the production-value growth rate based on the growth rates of the projector.

Table 1
Data sources for historical prices for the energy commodity group

	Prices (U.S. dollars)			Values (Canadian dollars)	
Commodity	**Source**	**Price per unit**	**Time period**	**Source**	**Time period**
Coal	Manthy (1978)[1]	Dollars per ton	1870 to 1972	Kolet and Macdonald (2010)[3]	1961 to 1972
				Historical Statistics of Canada (Quirin n.d.*a*)[4]	1870 to 1961
Natural gas	Manthy (1978)	Cents per million cubic feet	1919 to 1972	Kolet and Macdonald (2010)	1961 to 1972
				Historical Statistics of Canada (Quirin n.d.*b*)[5]	1919 to 1961
Crude petroleum	EIA (2017)[2]	Dollars per barrel	1870 to 1972	Kolet and Macdonald (2010)	1961 to 1972
				Historical Statistics of Canada (Quirin n.d.*b*)	1886 to 1961
				Regression-based prediction[6]	1870 to 1885

1. R.S. Manthy, 1978, *Natural Resource Commodities—A Century of Statistics: Prices, Output, Consumption, Foreign Trade, Employment in the United States 1870-1973.*

2. EIA (U.S. Energy Information Administration), 2017, *U.S. Crude Oil First Purchase Price, Dollars per Barrel.*

3. I. Kolet and R. MacDonald, 2010, *The Fisher BCPI: The Bank of Canada's New Commodity Price Index.*

4. J.D. Quirin, n.d.*a*, "Section P: Mining," *Historical Statistics of Canada.*

5. J.D. Quirin, n.d.*b*, "Section Q: Energy and Electric Power," *Historical Statistics of Canada.*

6. Regression-based prediction of historical growth rates from production values and EIA prices.

Source: Statistics Canada, author's compilations.

2.2 Metals and minerals

Historical estimates of prices for metals and minerals are drawn from three sources (Table 2). Gold, silver and nickel prices are taken from the data collected for Coletti (1992). Prices for copper, zinc and lead are taken from Manthy (1978), while prices for aluminum and potash are taken from the U.S. Geological Survey (Kelly and Matos 2014). Data for iron prices come from the U.S. Geological Survey for the period from 1900 to 1972. For the years 1870 to 1900, the pig iron price index from Manthy (1978) is used to back-cast the price. Although the pig iron price represents a more manufactured price for iron than the ore price from the U.S. Geological Survey, there exists a correlation in the growth rates of the two series for the period from 1901 to 1912 (0.73) reasonable enough to form a basis for historical linking.

Historical production values are derived from three sources. For the period from 1961 to 1973, production values are taken from Statistics Canada's input–output system (Statistics Canada, n.d.*c*) and CANSIM table 152-0005 (Statistics Canada, n.d.*d*). For years prior to 1961, production values for gold, silver, nickel, copper, zinc, lead and iron are taken from the *Historical Statistics of Canada* (Quirin, n.d.*a*), Series P1-26, "Canadian production of principal metallic minerals, 1886 to 1975". Aluminum is modeled based on exports from Series P27-58, "Canadian exports of principal metallic minerals, 1968 to 1977." Estimates for potash production come from CANSIM table 152-0005 (Statistics Canada n.d.*d*) and 512-0002 (Statistics Canada n.d.*e*).

Table 2
Data sources for historical prices for the metals and minerals commodity group

	Prices (U.S. dollars)			Values (Canadian dollars)	
Commodity	**Source**	**Price per unit**	**Time period**	**Source**	**Time period**
Gold	Coletti (1992)[1]	Dollars per ounce	1870 to 1971	Statistics Canada (n.d.*c*)[4]	1961 to 1972
				Historical Statistics of Canada (Quirin n.d.*a*)[5]	1886 to 1961
Silver	Coletti (1992)	Dollars per ounce	1870 to 1971	Statistics Canada (n.d.*c*)	1961 to 1972
				Historical Statistics of Canada (Quirin n.d.*a*)	1887 to 1961
Nickel	Coletti (1992)	Dollars per pound	1879 to 1971	Statistics Canada (n.d.*c*)	1961 to 1972
				Historical Statistics of Canada (Quirin n.d.*a*)	1889 to 1961
Copper	Manthy (1978)[2]	Cents per pound	1870 to 1972	Statistics Canada (n.d.*c*)	1961 to 1972
				Historical Statistics of Canada (Quirin n.d.*a*)	1886 to 1961
Aluminum	Kelly and Matos (2014)[3]	Dollars per ton	1900 to 1972	Statistics Canada (n.d.*c*)	1961 to 1972
				Quirin (n.d.*a*)	1904 to 1961
Zinc	Manthy (1978)	Cents per pound	1870 to 1972	Statistics Canada (n.d.*c*)	1961 to 1978
				Historical Statistics of Canada (Quirin n.d.*a*)	1898 to 1961
Lead	Manthy (1978)	Cents per pound	1870 to 1972	Statistics Canada (n.d.*c*)	1961 to 1972
				Historical Statistics of Canada (Quirin n.d.*a*)	1887 to 1961
Iron	Kelly and Matos (2014)	Dollars per ton	1900 to 1972	Statistics Canada (n.d.*c*)	1961 to 1972
	Manthy (1978)	Pig iron index	1870 to 1900	*Historical Statistics of Canada* (Quirin n.d.*a*)	1887 to 1961
Potash	Kelly and Matos (2014)	Dollars per ton	1900 to 1972	Statistics Canada (n.d.*d*)[6], Statistics Canada (n.d.*e*)[7]	1966 to 1961

1. D. Coletti, "The Long-run Behaviour of Key Canadian Non-energy Commodity Prices (1900 to 1991)."
2. R.S. Manthy, 1978, *Natural Resource Commodities—A Century of Statistics: Prices, Output, Consumption, Foreign Trade, Employment in the United States 1870-1973*.
3. T.D. Kelly and G.R. Matos, compilers, 2014, *Historical statistics for mineral and material commodities in the United States (2016 version)*.
4. Statistics Canada, n.d.*c*, *Table 381-0009 Inputs and Outputs, by industry and commodity, L-level aggregation and North American Industry Classification System (NAICS), annual (dollars x 1,000,000)*.
5. J.D. Quirin, n.d.*a*, "Section P: Mining," *Historical Statistics of Canada*.
6. Statistics Canada, n.d.*d*, *Table 152-0005 Principal statistics of mineral industries, by North American Industry Classification System (NAICS), annual (dollars unless otherwise noted)*.
7. Statistics Canada, n.d.*e*, *Table 152-0002 Principal statistics of the mineral industries, annual (dollars unless otherwise noted)*.

Source: Statistics Canada, author's compilations.

2.3 Forestry

Historical price estimates for forestry commodities are drawn from a number of sources (Table 3). Lumber prices are taken from Manthy (1978) for the years 1870 to 1973. Pulp prices are taken from Manthy (1978) for the years 1916 to 1973. To increase the range of the price data, Urquhart's (1993) price for pulp is converted from Canadian dollars to U.S. dollars and used to back-cast the price series between 1875 and 1915. Prices for newsprint are back-cast using the Bureau of Labor Statistics (BLS) newsprint price index (BLS n.d.*b*) between 1947 and 1971. For the years

1890 to 1946, the National Bureau of Economic Research newsprint price (NBER n.d.*a*, *b*, *c*, *d*) is used to project prices historically.

Historical production values for forestry commodities are drawn from Statistics Canada's input–output tables for the years 1961 to 1972 (Statistics Canada, n.d.*c*). Estimates from the *Historical Statistics of Canada* (Osborn n.d.) are used between 1908 and 1960. There is no overlapping period for lumber or newsprint values in 1961, so the levels from the input–output tables and the *Historical Statistics of Canada* (Osborn n.d.) are used as published. For the years before 1908, estimates of forestry production from Urquhart (1993) are used to back-cast the levels from the *Historical Statistics of Canada* (Osborn n.d.). For pulp, export prices and production values are used to interpolate for 1961 and production values are then used to back-cast to 1917. From 1880 to 1917, estimates from Urquhart (1993) are employed to back-cast production values.

Table 3
Data sources for historical prices for the forestry commodity group

	Prices (U.S. dollars)			Values (Canadian dollars)	
Commodity	**Source**	**Price per unit**	**Time period**	**Source**	**Time period**
Lumber	Manthy (1978)[1]	Dollars per thousand board feet	1870 to 1973	Statistics Canada (n.d.*c*)[8]	1961 to 1973
				Historical Statistics of Canada (Osborn n.d.)[9]	1908 to 1960
				Urquhart (1993)	1870 to 1908
Pulp	Manthy (1978)	Dollars per cord	1916 to 1973	Statistics Canada (n.d.*c*)	1961 to 1973
	Urquhart (1993)[2]	Canadian dollar price converted to U.S. dollars	1875 to 1916	*Historical Statistics of Canada* (Osborn n.d.)	1917 to 1961
				Urquhart (1993)	1880 to 1917
Newsprint	BLS (n.d.*b*)[3]	Index	1947 to 1972	Statistics Canada (n.d.*c*)	1961 to 1973
	NBER (n.d.*a*, *b*, *c*, *d*)[4,5,6,7]	Cents per pound	1890 to 1947	*Historical Statistics of Canada* (Osborn n.d.)	1917 to 1960
				Urquhart (1993)	1870 to 1917

1. R.S. Manthy, 1978, *Natural Resource Commodities—A Century of Statistics: Prices, Output, Consumption, Foreign Trade, Employment in the United States 1870-1973.*

2. M.C. Urquhart, 1993, *Gross National Product, Canada: 1870-1926: The Derivation of the Estimates.*

3. BLS (Bureau of Labor Statistics), n.d.*b*, *PPI Commodity Data including "headline" FD-ID indexes* (for Pulp, paper and allied products – Newsprint).

4. NBER (National Bureau of Economic Research), n.d.*a*, "m04093a, U.S. Wholesale Price of Newsprint Paper 01/1890 –12/1915," *NBER Macrohistory: IV. Prices.*

5. NBER (National Bureau of Economic Research), n.d.*b*, "m04093b, U.S. Wholesale Price of Newsprint Paper Rolls, Contract, F.O.B. Mill 01/1914 –08/1919, 03/1920–12/1928," *NBER Macrohistory: IV. Prices.*

6. NBER (National Bureau of Economic Research), n.d.*c*, "m04093c, U.S. Wholesale Price of Newsprint Paper 01/1926 –12/1951," *NBER Macrohistory: IV. Prices.*

7. NBER (National Bureau of Economic Research), n.d.*d*, "m04093d, U.S. Wholesale Price of Newsprint Paper 01/1947 –02/1958," *NBER Macrohistory: IV. Prices.*

8. Statistics Canada, n.d.*c*, *Table 381-0009 Inputs and outputs, by industry and commodity, L-level aggregation and North American Industry Classification System (NAICS), annual (dollars x 1,000,000).*

9. B.S. Osborn, n.d., "Section L: Lands and Forests," *Historical Statistics of Canada.*

Source: Statistics Canada, author's compilations.

2.4 Agriculture

Historical agriculture prices are predominantly derived from Manthy (1978) (Table 4). Prices for cattle only are used as a proxy for prices for cattle and calves. Price series for cattle, hogs, wheat, barley, corn and potatoes extend from 1870 to 1973. U.S. dollar prices for canola are derived from Statistics Canada data (Statistics Canada, n.d.*b*) by multiplying the average farm price in Canadian dollars by the U.S.–Canada exchange rate.

Historical values for agricultural production are derived from a number of sources: Statistics Canada (n.d.*b*, *c*), the *Historical Statistics of Canada* (Trant n.d.), and Urquhart (1993).

Values for hogs and cattle and calves come from linking input–output estimates to estimates from the *Historical Statistics of Canada* (Trant n.d.) and Urquhart (1993). For each commodity, the growth rates of nominal estimates are used to back-cast the level of production from the 1972 value used to calculate the current BCPI.

For wheat, an index of the nominal value of wheat production is calculated by multiplying wholesale market prices for wheat by the thousands of bushels produced from the *Historical Statistics of Canada* (Trant n.d.). The growth rates from the index values are then used to back-cast the value of wheat production found in the input–output tables (Statistics Canada n.d.*c*).

For barley, estimates of the number of tons produced are multiplied by the price per tonne, to estimate the nominal value of production from 1908 to 1973. Growth rates from nominal farm sales of barley from Urquhart (1993) are then used to back-cast production values to 1870.

Estimates for the value of canola production for the years 1949 to 1973 are taken directly from the *Historical Statistics of Canada* (Trant n.d.), while estimates for corn are derived by summing the value of production of corn for grain and corn for fodder. For each type of corn, the number of tonnes produced is multiplied by the average farm price per tonne.

Potato gross farm values are from the *Historical Statistics of Canada* (Trant n.d.) for 1908 to 1973. Growth rates from Urquhart (1993) are used to back-cast the 1870-to-1907 period.

Table 4
Data sources for historical prices for the agriculture commodity group

	Prices (U.S. dollars)			Values (Canadian dollars)	
Commodity	**Source**	**Price per unit**	**Time period**	**Source**	**Time period**
Cattle and calves	Manthy (1978)[1]	Dollars per hundredweight	1870 to 1973	Statistics Canada (n.d.c)[4]	1961 to 1973
				Historical Statistics of Canada (Trant n.d.)[5]	1914 to 1975
				Urquhart (1993)[6]	1870 to 1914
Hogs	Manthy (1978)	Cents per pound	1870 to 1973	Statistics Canada (n.d.c)	1961 to 1973
				Historical Statistics of Canada (Trant n.d.)	1914 to 1975
				Urquhart (1993)	1870 to 1914
Wheat	Manthy (1978)	Dollars per bushel	1870 to1973	Statistics Canada (n.d.c)	1961 to 1973
				Historical Statistics of Canada (Trant n.d.)	1870 to 1973
Barley	Manthy (1978)	Dollars per bushel	1870 to 1973	Statistics Canada (n.d.*b*)	1908 to 1973
				Urquhart (1993)	1870 to 1909
Canola	Statistics Canada (n.d.*b*)[2]	Average Canadian dollar farm price (dollars per tonne) converted to U.S. dollars[3]	1949 to 1973	*Historical Statistics of Canada* (Trant n.d.)	1949 to 1973
Corn	Manthy (1978)	Dollars per bushel	1870 to 1973	Statistics Canada (n.d.*b*)	1908 to 1973
Potatoes	Manthy (1978)	Dollars per hundredweight	1870 to 1973	*Historical Statistics of Canada* (Trant n.d.)	1908 to 1973
				Urquhart (1993)	1870 to 1909

1. R.S. Manthy, 1978, *Natural Resource Commodities—A Century of Statistics: Prices, Output, Consumption, Foreign Trade, Employment in the United States 1870-1973.*

2. Statistics Canada, n.d.*b*, *Table 001-0010 Estimated areas, yield, production and average farm price of principal field crops, in metric units, annual.*

3. Average Canadian dollar farm price converted to U.S. dollars, using the U.S.–Canadian average monthy exchange rate.

4. Statistics Canada, n.d.*c*, *Table 381-0009 Inputs and outputs, by industry and commodity, L-level aggregation and North American Industry Classification System (NAICS), annual (dollars x 1,000,000).*

5. G.I. Trant, n.d., "Section M: Agriculture," *Historical Statistics of Canada*.

6. M.C. Urquhart, 1993, *Gross National Product, Canada: 1870-1926: The Derivation of the Estimates.*

Source: Statistics Canada, author's compilations.

2.5 Fisheries

The fisheries component of the historical index comprises only finfish (Table 5). Prices are based on the BLS finfish price index (BLS n.d.*a*), which is the same index used in the BCPI. The annual values span the period from 1947 to the present, and values from the earliest data to 1972 are used for the historical BCPI. Estimates for the value of finfish production come from the *Historical Statistics of Canada* Morse (n.d.) for the years 1906 to 1972.

Table 5
Data sources for historical prices for the fish commodity group

	Prices (U.S. dollars)			Values (Canadian dollars)	
Commodity	**Source**	**Price per unit**	**Time period**	**Source**	**Time period**
Finfish	BLS (n.d.*a*)[1]	Finfish price index	1947 to 1973	*Historical Statistics of Canada* (Morse n.d.)[2]	1908 to 1972

1. BLS (Bureau of Labor Statistics), n.d.*a*, *PPI Commodity Data including "headline" FD-ID indexes* (for Processed foods and feeds – Unprocessed finfish).

2. N.H. Morse, n.d., "Section N: Fisheries," *Historical Statistics of Canada*.

Source: Statistics Canada, author's compilations.

3 Methodology

The methodology for the historical BCPI has two components, which are discussed in the following two subsections. The first outlines the choice of index used in the calculation. The second details the choices of commodities to include in the index in a particular year.

3.1 Index calculations

The BCPI uses a chained Fisher index formula (Fisher 1922). The index was chosen for the BCPI to ensure conformity with other indexes currently in use (Kolet and Macdonald 2010) and because of its preferred properties (Diewert 1992). For consistency, the historical estimate of the index that is presented here uses the same Fisher formula as the modern BCPI. For the $i = 1,...,N$ commodities used in the historical index calculation, the Fisher price index between periods t and $t-1$ is defined as

$$BCPI_{t/t-1} \equiv \left(LP_{t/t-1} \times PP_{t/t-1}\right)^{1/2}, \tag{1}$$

Where LP is the Laspeyres price index and PP is the Paasche price index.

The Laspeyres index holds quantities fixed in the first period and allows prices to change. It is defined as

$$LP_{t/t-1} \equiv \sum \frac{p_t q_{t-1}}{p_{t-1} q_{t-1}} \tag{2}$$

The Paasche index holds quantities fixed in the second period and allows prices to change. It is defined as

$$PP_{t/t-1} \equiv \sum \frac{p_t q_t}{p_{t-1} q_t} \tag{3}$$

The value for the Fisher index for each pair of years, beginning with 1870 and 1871 and concluding with 1971 and 1972, is calculated. The link values are then used to chain the BCPI historically back to 1870 as

$$\frac{1}{BCPI_{t/t-1}} \times BCPI_t^{Level\ Index} \tag{4}$$

The same calculation is applied to each of the sub-indexes to create historically chained versions of the BCPI for energy, for metals and minerals, for forestry and for agriculture. The chain values for the BCPI for fisheries consist only of the price series for finfish from the BLS. Consequently, the finfish price index growth rates are used to historically chain the modern series without the need for a Fisher index calculation.

3.2 Sample size

Through time, the composition of Canada's commodity output changes, as new commodities are extracted, grown or produced. As a result, the commodity basket used to calculate the historical BCPI evolves over time. The practice adopted here for the historical BCPI is to add new commodities as they enter into production. To include a new commodity in the index, it must be in production for two consecutive years, as this is the span necessary to calculate the index.

There are two other factors that cause additional complications for constructing the index.

The first relates to data constraints. To include a commodity in the index requires two consecutive years of data on its price and the value of its production. In some cases, prices exist for the whole 1870-to-1972 period, but data on the value of production are lacking, even though production is known to have occurred. This is particularly the case for mining. Data on the value of mineral production used in the index begin between 1886 and 1889 for most mineral components. Prior to 1886, there do not appear to be measures of mineral production even though historical events in mining can be traced back to at least 1604 (Cranstone 2002). As a consequence, particular periods show an increase in the number of commodities that does not correspond with an onset of production, but rather with the advent of the publication of data.

The second complicating factor is iron ore. Iron ore production in Canada goes through a number of periods of production followed by periods when production stops. This on-again, off-again feature of iron ore production means that it repeatedly enters and exits the commodity bundle used to calculate the historical BCPI.

The pattern of expansion and contraction in the number of commodities in the commodity bundle used for the historical BCPI means that one of two strategies can be used for the index calculation.

One strategy is to use only those commodities for which there are data for the entire 1870-to-1972 period. This strategy greatly reduces the available commodity bundle and is not adopted here.

The alternative strategy is to adjust the commodity bundle used to calculate the index as new commodities are developed or as new data sources become available. The historical BCPI and its sub-indexes for energy, for metals and minerals, for forestry and for agriculture therefore have commodity bundles that expand and contract as commodity production evolves. The sub-index for fisheries does not evolve, as it is based only on finfish prices from the BLS (BLS n.d.a). However, when linked with the BCPI, the bundle expands in 1972/1973, when shellfish is added.

The process used to adjust the commodity bundle is shown in Table 6 for the historical BCPI and its sub-aggregate indexes. The calculations begin with a restricted set of commodities in 1870, and then are adjusted through time. The early period, particularly around 1886, has a more rapid expansion of the commodity bundle, as data on metals and minerals become available. Additions of commodities such as aluminum, potash and canola occur once production begins. Iron ore production in Canada goes through a number of starts and stops, and iron is the only commodity to repeatedly enter and exit the commodity bundle.

Table 6
Additions and subtractions to the Bank of Canada commodity price index through time

Year	Bank of Canada commodity price index	Bank of Canada commodity price index, sub-indexes				
		Energy	Forestry	Metals and minerals	Agriculture	Fish
1870	Begin index with coal, oil, lumber, wheat, barley, potatoes, cattle, hogs	Begin index with coal, oil	Begin index with lumber	...	Begin index with wheat, barley, potatoes, cattle, hogs	...
1880/1881	Add pulp	...	Add pulp	...	...	...
1886/1887	Add gold, copper	...	...	Begin index with gold, copper	...	...
1887/1888	Add silver, lead, iron	...	...	Add silver, lead, iron	...	...
1889/1890	Add nickel	...	...	Add nickel	...	...
1890/1891	Add newsprint	...	Add newsprint	...	...	...
1899/1900	Subtract iron	...	...	Subtract iron	...	...
1902/1903	Add zinc	...	...	Add zinc	...	...
1904/1905	Add aluminum	...	...	Add aluminum	...	...
1906/1907	Add iron	...	...	Add iron	...	...
1909/1910	Add corn	...	...	...	Add corn	...
1919/1920	Add natural gas	Add natural gas	...	...	...	...
1923/1924	Subtract iron	...	...	Subtract iron	...	...
1939/1940	Add iron	...	...	Add iron	...	...
1947/1948	Add finfish	...	...	...	...	Begin index with finfish
1949/1950	Add canola	...	...	...	Add canola	...
1966/1967	Add potash	...	...	Add potash	...	...
1972/1973	Add shellfish	...	...	...	...	Add shellfish

... not applicable
Source: Statistics Canada, author's compilations.

4 Historical estimates

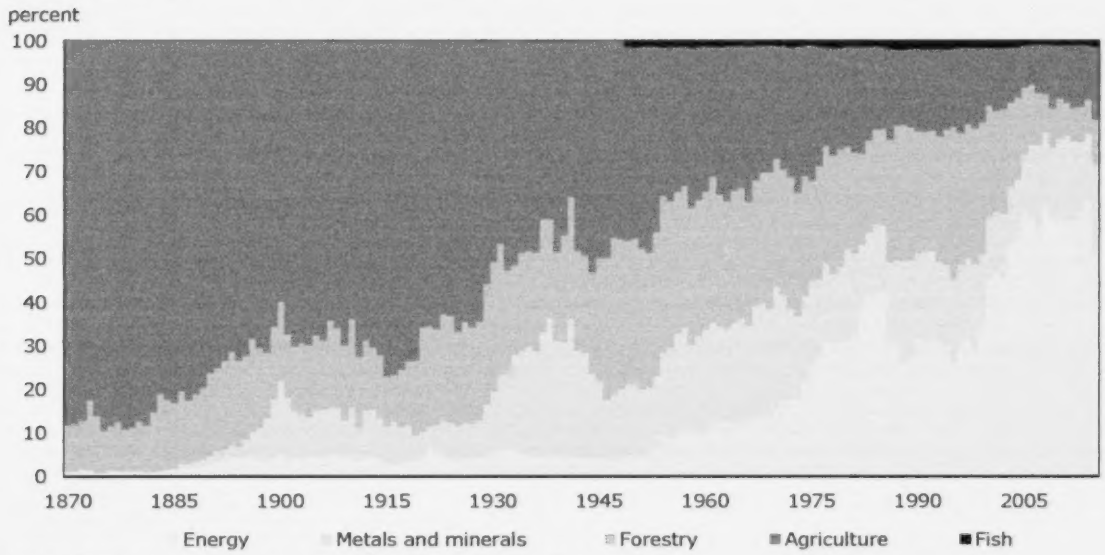
The data on the historical BCPI provide information on two dimensions pertinent for calculating the historical index: information on production shares and the index values. Both dimensions are presented below. In all cases, historical BCPI values are linked to the BCPI to create a long-run BCPI that covers the period from 1870 to 2015. The information presented on production shares below focuses only on the data employed to create the long-run BCPI. In some cases, additional data exist on production shares, but it is not reported as it does not contribute to the index calculation.

4.1 Bank of Canada commodity price index shares

One major advantage of using a chained index formula is that it constantly updates itself for changes in the production composition and, thus, includes information on the extent of these changes. In broad terms, the composition of the commodities included in the long-run BCPI, in terms of the value of production in Canadian dollars, has changed greatly over the 145 years for which data are available (Chart 1).

Initially, commodity production was dominated by agricultural output. This is the case both because the majority of commodity production was derived from agricultural products at the time, and because there is limited information available for the first 15 years, particularly about mining and mineral commodities. The other major source of commodity production in the early period was forestry.

Chart 1
Composition of the BCPI by major commodity group used in the long-run BCPI



Note: BCPI stands for Bank of Canada commodity price index.
Source: Statistics Canada, author's calculations.

Over time, production shifted toward new commodity groups: first forestry, then metals and minerals, and finally energy.

Forestry production gained importance through the first 80 years of the sample, as new publishing industries in the United States, particularly newspapers, created increased demand for pulp and paper, and as new production techniques, transportation infrastructure and trade agreements permitted the increased demand to be met from Canadian supply. The share of forestry in long-run BCPI commodity production peaked just after the Second World War, after which the contribution from forestry products began a slow decline. Other commodities, particularly oil, gained prominence. Forestry experienced a brief resurgence in its share of long-run BCPI commodity production in the 1980s and 1990s, but fell away rapidly after 1999, as demand for paper products in the United States declined with the widespread market penetration of electronic media.

Data on mining and mineral commodities begin to enter the long-run index calculation in 1886. Initially, there was little impact on the composition of production from metals and minerals. By 1891, the value of mining had reached 2.57% of production and proceeded to rise rapidly as the Klondike Gold Rush in Yukon led to an increase in gold extraction. As the gold fields played out, the relative value of metal and mineral production declined, even as additional commodities were added to the long-run index. The next large adjustment came during the Great Depression. A combination of weak agricultural prices and, in the mid-1930s, an attempt by the Federal Reserve to jump-start inflation by revaluing gold helped increase the share of metal and mineral production in the index. After the recovery in agricultural prices, the share of production in the long-run BCPI commodity bundle derived from metals and minerals declined by around half. The share of production then expanded through the 1950s and 1960s to reach a high point in 1970, before tending to decline until the end of the period.

Energy products have the most dramatic effect on the overall composition of commodity production in the latter half of the 20th century, across all long-run BCPI subgroups. After rising modestly through the first 80 years, the share of energy production rose rapidly after 1947. Initially, the increased share of energy production in the BCPI commodity bundle coincided with a decline in the share of agricultural products. As time progressed, however, the share of production from energy began to erode the influence of forestry, and then metals and minerals.

4.2 Bank of Canada commodity price index subgroup shares by commodity

4.2.1 Energy

Across energy commodities, there is a transition from coal towards oil and natural gas over the 145 years presented (Chart 2).

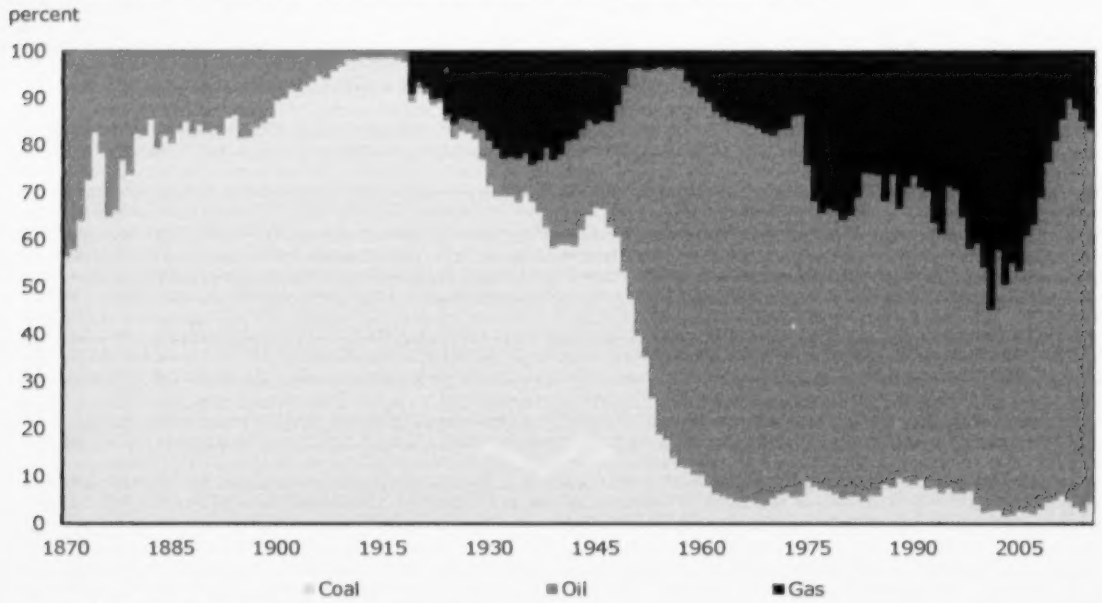
At the start of the period, production is almost equally split between coal and oil. However, oil had a high price over the first 15 years of the sample that declined as production rose, so, while its production share is large, the quantity of oil produced was minor.[2] During this part of the sample period, the oil industry in Canada was centered in Ontario, where, for example, the area around Oil Springs experienced an oil boom in the mid-1880s. As the oil played out, production and its share of output in the BCPI declined until the 1920s, when oil production began around Norman Wells in the Northwest Territories. But, it was not until 1947, when oil was discovered at Leduc, Alberta, that oil became the major source of energy production in Canada.

After the expansion of oil production that occurred in Alberta and Saskatchewan in the 1950s and 1960s, the share of energy production from natural gas began to increase. This was a return to a 50-year trend that was interrupted by the rapid expansion of oil production in the middle of the

2. Data for natural gas production extend prior to the first data shown in Chart 2. These estimates are not shown as they do not enter the index calculation, but they do contribute to energy production and lower the relative importance of coal production in the years spanning 1892 to 1918.

century. During the resource boom of the 2000s, the trend was again interrupted as the share of oil in production increased rapidly.

Chart 2
Composition of energy commodities used in the long-run BCPI



Note: BCPI stands for Bank of Canada commodity price index.
Source: Statistics Canada, author's calculations.

4.2.2 Metals and minerals

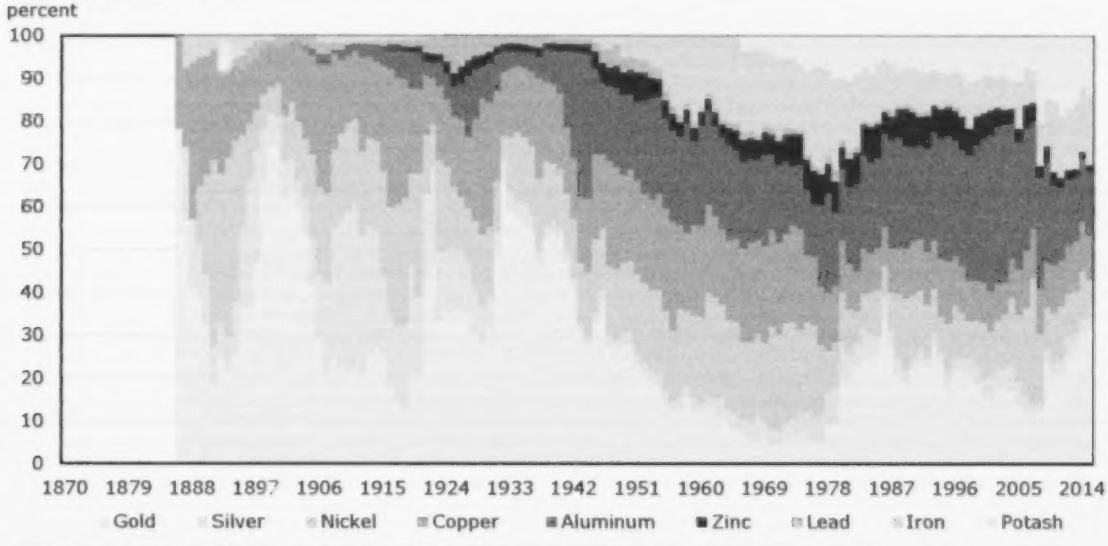
Production shares for commodities in the long-run BCPI commodity bundle evolve over time as production starts or stops, and as data sources become available. Data for metals and minerals begin in 1886 with gold and copper, and expand to include silver, lead and iron in 1887 (Chart 3). Nickel enters the index in 1890, zinc in 1903, aluminum in 1905 and potash in 1967. Iron ore exits the index due to production cessation in 1900 and 1924, and re-enters the index in 1907 and 1940.

Production shares for metals and minerals exhibit features similar to those of production shares for agricultural commodities. There is an expansion through time in the number of commodities that affects the relative importance of each particular commodity. This occurs as new technologies, infrastructure, mineral discoveries and shifts in demand lead to changes in the composition of production. For example, transforming bauxite into aluminum requires significant quantities of electricity. As a result, the production share of aluminum increases as power sources become available to production.

Production changes affect relative shares, as in gold production, for example. Gold production constitutes a high proportion of overall production in the early part of the period. In the 1886-to-1890 period, this is the case partly because there is data on fewer commodities, but also because the Fraser River Gold Rush increased production. A similar event occurred in the late 1890s and early 1900s, as the Klondike Gold Rush drew people to the gold fields of Yukon. In the 1930s, the decision by the U.S. Federal Reserve to revalue gold from US$20.67 to US$35.00 per ounce led to a gold boom in Canada, and the share of gold production rose accordingly.

Through the period of stability in the 1950s and 1960s covered by the Bretton Woods period, gold production as a share of minerals and metals production declined to its lowest point. This period imposed price controls and trade restrictions on gold, and its cessation in the 1970s led to rapidly rising gold prices. This change is reflected in a rising share of gold in metals and minerals production, while the period of weak prices through the 1990s sees a relative decline. The share of gold production then rises through the 2000s as gold prices once again increased sharply.

Chart 3
Composition of metals and minerals commodities used in the long-run BCPI

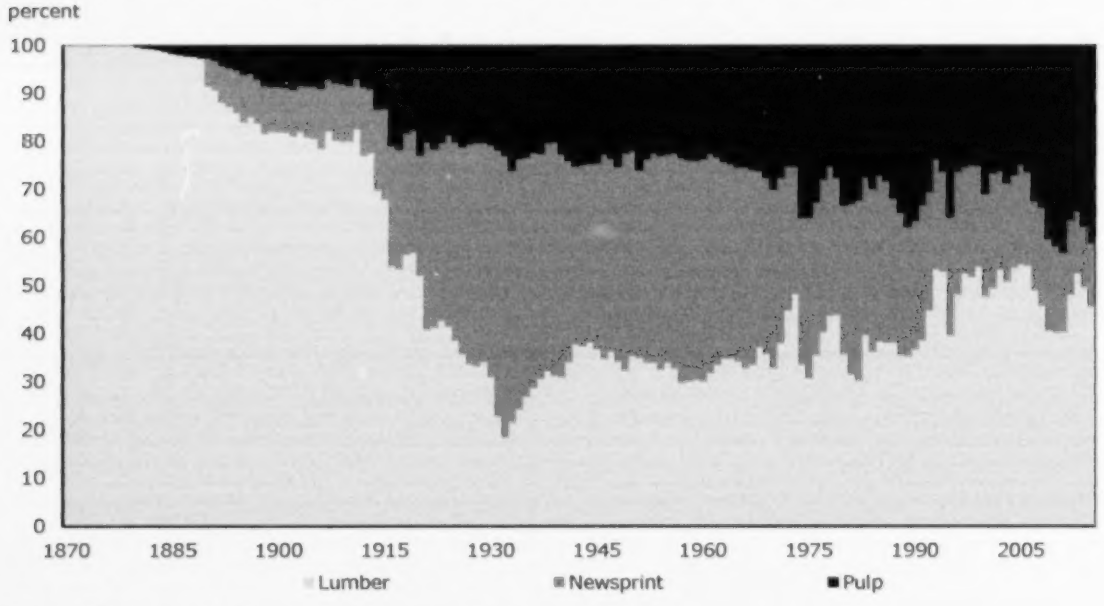


Note: Data available starting in 1886. BCPI stands for Bank of Canada commodity price index.
Source: Statistics Canada, author's calculations.

4.2.3 Forestry

Across forestry commodities in the long-run BCPI, the largest source of adjustment comes from the emergence and evolution of publishing industries and their demand for newsprint and pulp and paper (Chart 4). Beginning around the end of the First World War and stabilizing by the late 1930s, a transition in the composition of production away from lumber towards pulp and paper and newsprint occurred. The production of newsprint and pulp and paper was the majority of production of forestry products until the 1990s, when the relative share of lumber began to rise, and the share of newsprint began to decline quickly.

Chart 4
Composition of forestry commodities used in the long-run BCPI



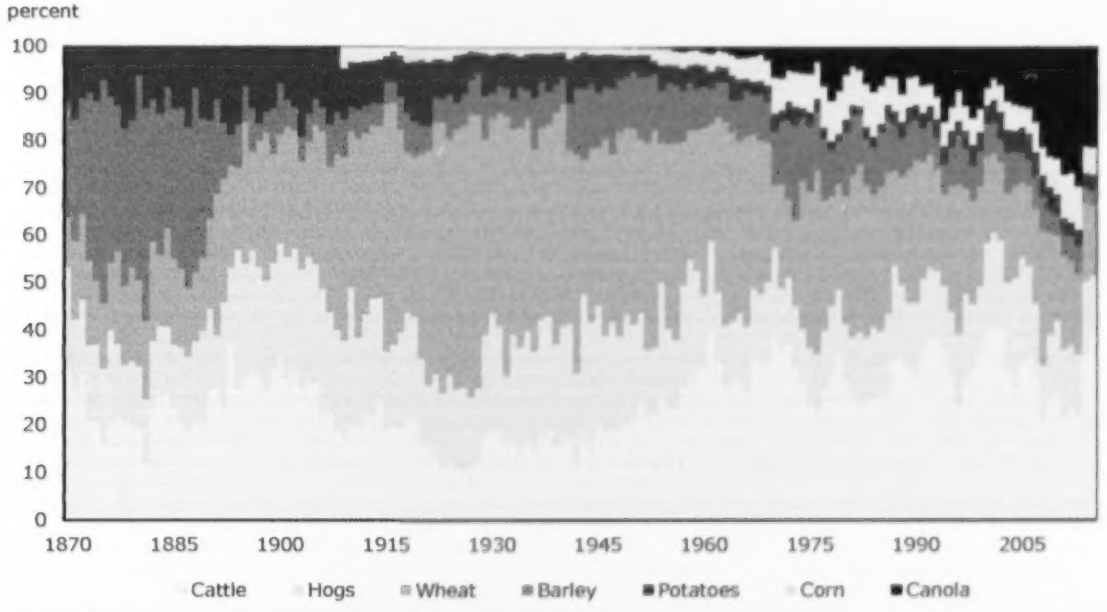
Note: BCPI stands for Bank of Canada commodity price index.
Source: Statistics Canada, author's calculations.

4.2.4 Agriculture

The agricultural commodities included in the long-run BCPI are a select number of agricultural outputs that have particular economic significance (Chart 5). Nevertheless, the major events that affected agricultural production over the last 145 years are encapsulated in the commodities included here. Events such as the Wheat Boom of the late 1800's and early 1900's or the increasing importance of oilseeds (represented by canola) can be seen in the share of agricultural commodities included in the historical index. Similarly, the importance of animal production, which typically makes up nearly 40% of the weight in the BCPI for agriculture, can be seen.

While particular products, such as wheat or cattle, have an important place in agriculture over the entire time period, their relative size is not fixed. While year-to-year fluctuations in prices or production can lead to changes in the share of a particular commodity, a more important change has been the evolution that agriculture has undergone in Canada. In response to new developments, from infrastructure that opened the Prairies to research and development that made new crop types available, agricultural production moved first towards wheat and later towards oilseeds.

Chart 5
Composition of agricultural commodities in the long-run BCPI



Note: BCPI stands for Bank of Canada commodity price index.
Source: Statistics Canada, author's calculations.

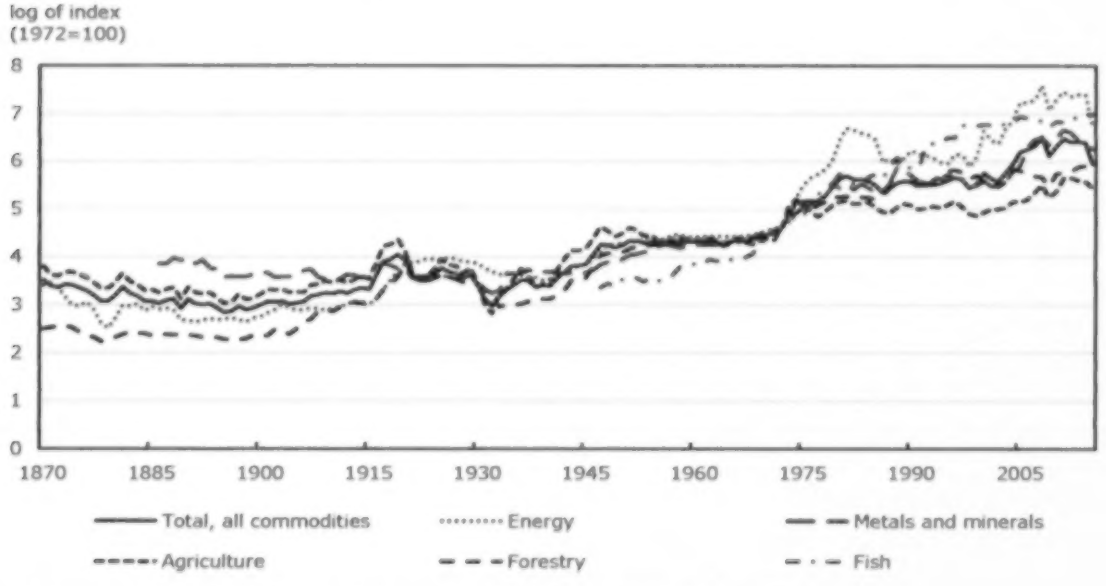
4.3 Examining the utility of the long-run Bank of Canada commodity price index: 1870 to 2015

The historical chain index values that have been linked to the modern BCPI are shown in Chart 6, and the accompanying compound annual growth rates by decade are reported in Table 7. To examine the utility of the index calculations, two approaches are taken. In both approaches, the goal is to understand the characteristics of the long-run BCPI, to identify the types of uses it is most appropriate for.

The first approach examines the behaviour of the historical BCPI values with respect to major economic events.

The second approach compares the long-run BCPI values with two other indexes: an export index for Canada from 1870 to the present that is an updated version of the index from Baldwin and Macdonald (2012), and the General Wholesale Price Index (including gold) for the period from 1870 to 1975 from the *Historical Statistics of Canada* (Holmes n.d.). This comparison is performed only at an aggregate level, as experience has shown that this level has the greatest consistency when making comparisons across indexes or between values from different time periods and methodologies.

Chart 6
Bank of Canada commodity price index



Source: Statistics Canada, author's calculations based on CANSIM table 383-0027.

Table 7
Growth rates by decade

	Bank of Canada commodity price index					
Period	Total, all commodities	Energy	Metals and minerals	Agriculture	Forestry	Fish
			percent			
1870 to 1880	-3.1	-6.5	...	-3.2	-1.8	...
1880 to 1890	-0.9	-0.6	...	-1.2	0.6	...
1890 to 1900	-1.1	0.8	-3.1	-1.3	0.2	...
1900 to 1910	2.4	1.7	-1.1	2.5	4.8	...
1910 to 1920	7.3	9.9	2.2	6.6	10.0	...
1920 to 1930	-5.0	0.0	-2.9	-6.1	-3.9	...
1930 to 1940	-0.3	-3.1	2.2	-1.0	-2.9	...
1940 to 1950	8.9	7.7	2.6	11.7	10.2	...
1950 to 1960	0.9	1.3	3.2	-1.5	2.3	3.4
1960 to 1970	1.5	1.2	3.4	0.5	1.1	5.5
1970 to 1980	12.3	21.0	12.4	7.9	8.5	11.1
1980 to 1990	-0.4	-2.1	-0.6	-0.8	3.3	4.5
1990 to 2000	1.7	4.3	-1.0	-1.4	0.6	9.1
2000 to 2010	5.7	6.9	9.3	4.4	1.1	0.8
2010 to 2015	-7.1	-10.5	-4.2	1.9	0.7	3.0

... not applicable
Source: Statistics Canada, author's compilations.

4.3.1 Historical Bank of Canada commodity price index versus historical events

The first step in assessing the utility of the historical BCPI estimates is to examine the extent to which major historical events are captured. Because historical index values are estimated from a number of projectors, it is important to verify that major events important to the history of commodity prices are represented in the long-run estimates, to ensure that the back-casting methodology produces relevant results for the historical period. For example, the years 1929 to 1933 are expected to show deflation that is among the largest on record, with agriculture prices more affected than other prices.

In the first decade and a half, from 1870 to the mid-1880s, there is a general decline in the historical BCPI and its sub-indexes. This corresponds to a period of deflation in the United States and an appreciation of the Canadian dollar relative to the U.S. dollar, as the United States took action to return to the gold standard at pre-Civil War levels. It accomplished this in 1879 (Powell 2005).

The historical BCPI shows a rapid escalation of prices around the beginning of the First World War, followed by a reduction after the war (see Statistics Canada 2015; Bertram and Percy 1979). The onset of the Great Depression is similarly represented by a decline in historical index values between 1929 and 1932. The historical BCPI fell by 48.0% during these years, with the historical agricultural BCPI experiencing a particularly large decline of 61.4%.

The Second World War and its aftermath correspond with a period of strong price growth for the historical BCPI and all of its sub-indexes. Between 1939 and 1945, the historical BCPI rose by 55.5%, with the agriculture sub-index rising by 101.6%. Then, between 1945 and 1951, the historical BCPI rose by an additional 62.4%. These increases were then followed by a period of relative calm (the late 1950s) and slowly rising inflation rates (the 1960s). This "golden age" is also reflected in the historical index calculations.

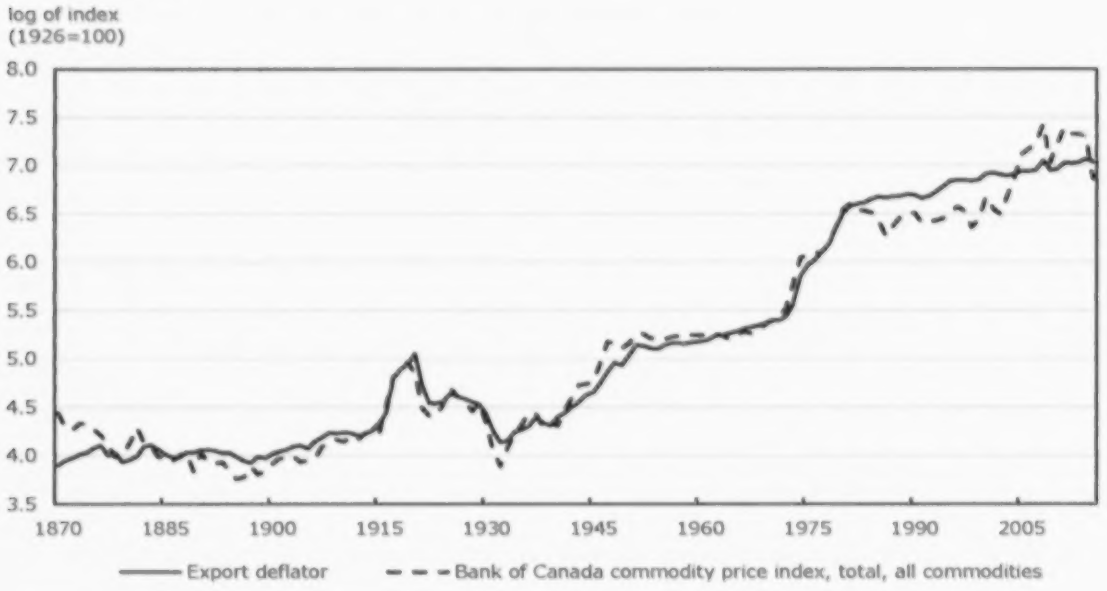
Based on general conditions throughout historical periods, the historical BCPI reflects the major events that influenced commodities important to Canada during the 1870-to-1971 period. Consequently, it is possible to draw the inference that the historical values of the index contain information consistent with macroeconomic phenomena.

4.3.2 Long-run Bank of Canada commodity price index versus historical price indexes

While the historical BCPI captures major historical events, its utility is greater if it reflects changes at an annual frequency and if the magnitude of its changes reflects the relative importance of particular events. Consequently, a second step for assessing the utility of the historical calculations is to link them to the BCPI and compare this long-run BCPI with other sources of information.

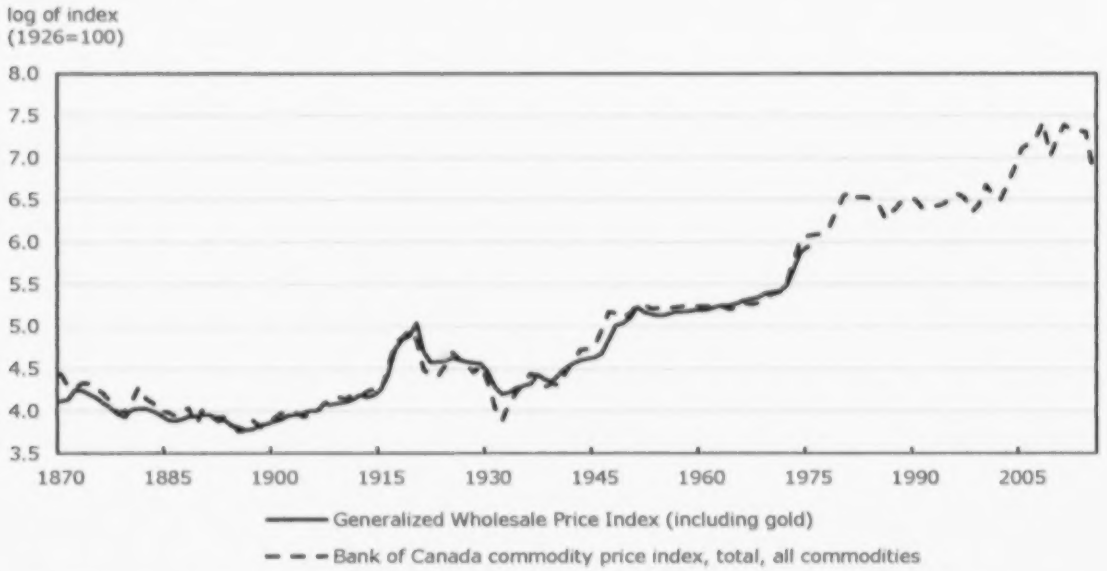
Here, two price indexes are compared with the long-run BCPI. The first comparison price index is an updated version of the long-run export deflator from Baldwin and Macdonald (2012) (Chart 7). Its time span permits a comparison with the long-run BCPI over the entire 1870-to-2015 period, and thus covers the BCPI and its historical estimates. The second is the Generalized Wholesale Price Index from the *Historical Statistics of Canada* (Holmes n.d.) (Chart 8), which covers historical estimates and the linking period of the early 1970s.

Chart 7
Long-run Bank of Canada commodity price index versus long-run export prices



Source: Statistics Canada, author's calculations based on CANSIM table 383-0027.

Chart 8
Long-run Bank of Canada commodity price index versus wholesale prices



Source: Statistics Canada, author's calculations, CANSIM table 383-0027 and Statistics Canada, n.d.*a*, *Historical Statistics of Canada*.

With respect to long-run export prices, a one-to-one correlation is not expected. This is because, while commodities are important for exports, exports also include finished and semi-finished products throughout the history of Canada (see Baldwin and Macdonald 2012), and because export prices are measured in Canadian dollars rather than U.S. dollars. For example, there is a significant increase in the long-run BCPI in the 2000s, as commodity prices increased. This translates into rising export prices, but not on the same scale as in the long-run BCPI, owing to the appreciation of the Canadian dollar (which offset some of the price increase in Canadian dollar terms) and to the effect of non-commodity exports, such as motor vehicles. Nevertheless, the movements found in the long-run BCPI do correlate with both the timing and magnitude of changes in export prices.

During the earliest part of the period, when the United States was deflating its economy after the Civil War, the price of exports shows little trend, while the long-run BCPI declines. This may reflect differences between the composition of commodities in the two indexes, differences between resource price changes and non-resource price changes, or differences in index construction, as the historical values for the export price index come from a fixed-weight series, while the long-run BCPI is chain-weighted.

Both the export prices and the long-run BCPI begin trending upward around 1895, and then follow very similar patterns over the course of the First World War, the 1920s and the onset of the Great Depression. The *Gold Reserve Act* of 1934 raised the value of gold from US$20.67 to US$35.00 per ounce, with the aim of increasing inflation in the United States. This change has a greater effect on the long-run BCPI than on the export price, because monitary gold is classified differently from commodity gold.

A minor difference occurs during the Second World War, as the long-run BCPI rises more quickly than export prices. The source of the difference is not immediately apparent, but may stem from the changing composition of trade towards munitions and armaments because of the war (Baldwin and Macdonald 2012) or from wartime government price controls that could have interrupted the usual peacetime links between supply, demand and price.

The stability of the 1950s and 1960s, as well as the rapid increase in prices of the 1970s and 1980s, are both reflected with similar timing and magnitude in export prices and in the long-run BCPI.

Finally, the latest commodity boom of the 2000s stands out because of the different paths of the two series, the first time this occurs on record. The export price index does not change its trajectory during the 2000s, while the long-run BCPI rises rapidly. This may reflect the path of non-resource exports or the effect of the floating exchange rate, as the commodity boom of the 2000s is the first in the history of Canada where there was no intervention from governments in the form of currency controls or price controls for energy products during a period of rising commodity prices.

The wholesale price[3] index exhibits a tighter relationship with the long-run BCPI than do export prices, but it is available only for a shorter time period. During the early part of the period, from 1870 to around 1895, the wholesale price index and the long-run BCPI both decline, with similar trends, and begin to rise at the same time after the mid-1890s. From this point to the onset of the First World War, they again share a similar trend. A difference then emerges in the year-to-year

3. While the wholesale price index is labelled as such, it is not related to wholesaling or to wholesale trade. According to the general note in the *Historical Statistics of Canada* (Holmes n.d.):
"The term wholesale price indexes may be ambiguous. The indexes include prices at various stages in the production and distribution of raw and processed materials, semi-finished goods and fully manufactured products. The prices relate to larger scale or bulk transactions. The indexes should not be interpreted therefore as relating to prices of 'wholesalers' or the 'wholesale trade.' Rather, the indexes measure movements of prices of a very broad but ill-defined mix of materials and products below the retail level."

variation through the 1920s and 1930s. The long-run BCPI exhibits more short-term volatility, which may be caused by compositional differences or the use of an improved, chain-weighted index formula. From the First World War to the end of the wholesale index in 1975, the long-run BCPI and the wholesale index exhibit essentially the same relationship as the BCPI and the export price deflator.[4]

The comparison of the long-run BCPI with export prices and wholesale prices supports the use of the index at an annual frequency. The year-to-year fluctuations in the long-run BCPI are reflected in other series, the magnitude of changes is in line with other data sources, and they share similar trends. Moreover, because the long-run BCPI is calculated using a chain-weighted index formula, its weights are more accurate than earlier data sources.

Based on their relationship with other indexes, the historical values for the long-run BCPI are judged to be of sufficient utility to merit their use at an annual frequency for economic analysis. The estimates do not exhibit time-series characteristics that are out of line with other data sources, and, as a result, they are useful as inputs for statistical and econometric models and for trend-cycle decompositions.

4.4 The behaviour of the long-run commodity price indexes between 1870 and 2015

This section describes a number of characteristics of the long-run BCPI. The discussions aim to illustrate properties of the long-run BCPI series, rather than long-run relationships, which require the construction of more complex models. Across metrics, the complete available dataset is always used. As a result, the number of observations is lower for the metals and minerals and fisheries sub-indexes, owing to their relative lack of data points.

4.4.1 Descriptive statistics for growth rates of the long-run indexes

For the long-run BCPI and for each of the sub-indexes, there is a positive skewness to the distributions of annual growth rates and a degree of kurtosis, indicating that the distributions have thick tails relative to the normal distribution (Table 8). In other words, the series are periodically subject to innovations that are larger than expected (based on a normal distribution), and positive innovations are larger than negative ones. The highest average annual growth rate is for fisheries, for which data are only available after the Second World War. The second-highest is for energy, followed by forestry, metals and minerals and agriculture. In each case, the median lies below the mean, and the skewness is positive for all sub-indexes. The implication is that the more extreme periodic positive shocks that occur raise the arithmetic average of the annual growth rates relative to the mid-point of the distribution.

Similarly, the periodic innovations that create the positive skewness and kurtosis have an outsized influence for measuring long-run growth rates. The influential observations can also create an impression of larger-than-actual growth rates across time, because they tend to bias estimates of average growth upwards, relative to compound annual growth rates based on the first and last periods available. Across the sub-indexes, the effect is present in all commodity groups.

4. One feature of the data that stands out for its lack of effect is the tariff structure prevalent during the period up to the Second World War. Through the early part of the period, Canada and the United States adjusted tariff rates (see McDonald, O'Brien and Callahan 1997). On the U.S. side, to name a few, there were the 1909 Payne–Aldrich tariff, the 1913 Underwood tariff, the 1922 Fordney–McCumber tariff and the much-studied 1930 Smoot–Hawley tariff. Although the aim of these tariffs was to affect domestic–international price structures, there is no noteworthy divergence between the index for the BCPI in U.S. dollars and indexes based on the Canadian dollar. This type of aggregate behaviour is consistent with a system where firms do not price up to the tariff, and with the results from Harris, Keay and Lewis (2015).

Table 8
Descriptive statistics on the distribution of the growth rates in the Bank of Canada commodity price index and its components

	Bank of Canada commodity price index					
	Total, all commodities	Energy	Metals and minerals	Agriculture	Forestry	Fish
Compound annual growth rate	1.68	2.34	1.89	1.15	2.28	5.48
Mean, annual growth rate	2.41	3.49	2.53	2.19	2.66	6.13
Median, annual growth rate	1.54	1.31	1.12	1.57	1.49	2.92
Standard deviation, annual growth rate	12.05	15.75	11.96	14.89	8.92	12.31
Skewness, annual growth rate	-0.01	0.99	1.25	0.68	0.64	1.51
Kurtosis, annual growth rate	3.97	7.58	5.51	4.67	4.10	7.44
Jarque–Bera test p-value	0.06	0.00	0.00	0.00	0.00	0.00
Years (number)	145	145	129	145	145	68

Source: Statistics Canada, author's compilations.

Table 9
Correlations of annual growth rates

	Bank of Canada commodity price index					
	Total, all commodities	Energy	Metals and minerals	Agriculture	Forestry	Fish
			annual correlation			
Bank of Canada commodity price index, total, all commodities	1.00	0.65	0.58	0.85	0.54	0.19
Energy	...	1.00	0.33	0.30	0.35	0.02
Metals and minerals	...	...	1.00	0.42	0.30	0.10
Agriculture	...	...	...	1.00	0.38	0.17
Forestry	...	...	...	...	1.00	0.22
Fish	...	...	...	...	...	1.00
			number			
Years	144	144	128	144	144	67

... not applicable

Source: Statistics Canada, author's compilations.

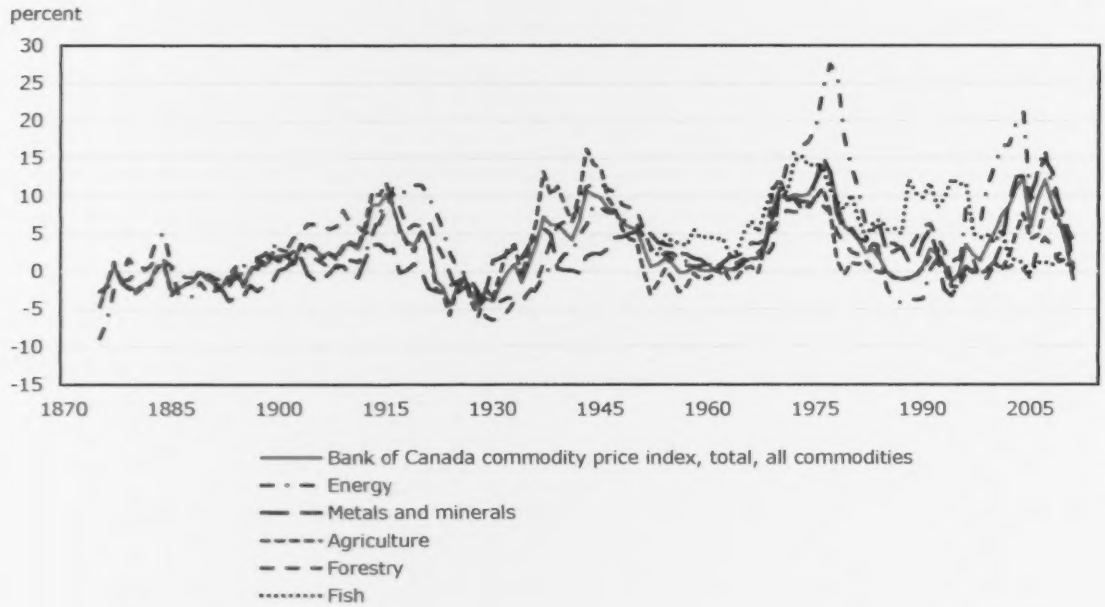
The effect of extreme events, particularly positive events, is sufficiently strong that the long-run growth-rate distributions do not appear to be normally distributed. Jarque–Bera tests for normality reject the null hypothesis of a normal distribution at conventional significance levels. The evidence against normality is weakest for the overall index, but quite strong for the sub-indexes

Across the sub-indexes, there is also a limited correlation in their annual growth rates (Table 9). The strongest correlation is between metals and minerals (0.42), while the weakest is between energy and fisheries (0.02). Agriculture and energy have the highest correlations with the long-run BCPI. Generally, annual frequency correlations show moderate to weak relationships between commodity types. In addition, the annual correlations are subject to influential data points, because of the same type of sensitivity the average estimates have, or that ordinary least squares estimates would have, owing to the skewness and kurtosis of the growth-rate distributions.

4.4.2 Periods of accelerated growth

While annual frequency correlations imply that commodity shocks are only modestly correlated across commodity groups, an examination of Chart 6 (the log levels of the indexes) shows a step-like path through time, with periods of rapid change interspersed with periods of calm. This pattern is present in the long-run BCPI and in all sub-indexes, except for fisheries. The pattern recurs repeatedly throughout the history of the long-run BCPI, but is most pronounced after 1900. Moreover, this pattern has a similar timing across all commodity types, except for fisheries. In other words, the pattern suggests that some form of common aggregate shock, rather than idiosyncratic commodity-specific shocks, is present, and that the effect is present over periods spanning multiple years.

Chart 9
Nine-period central moving average



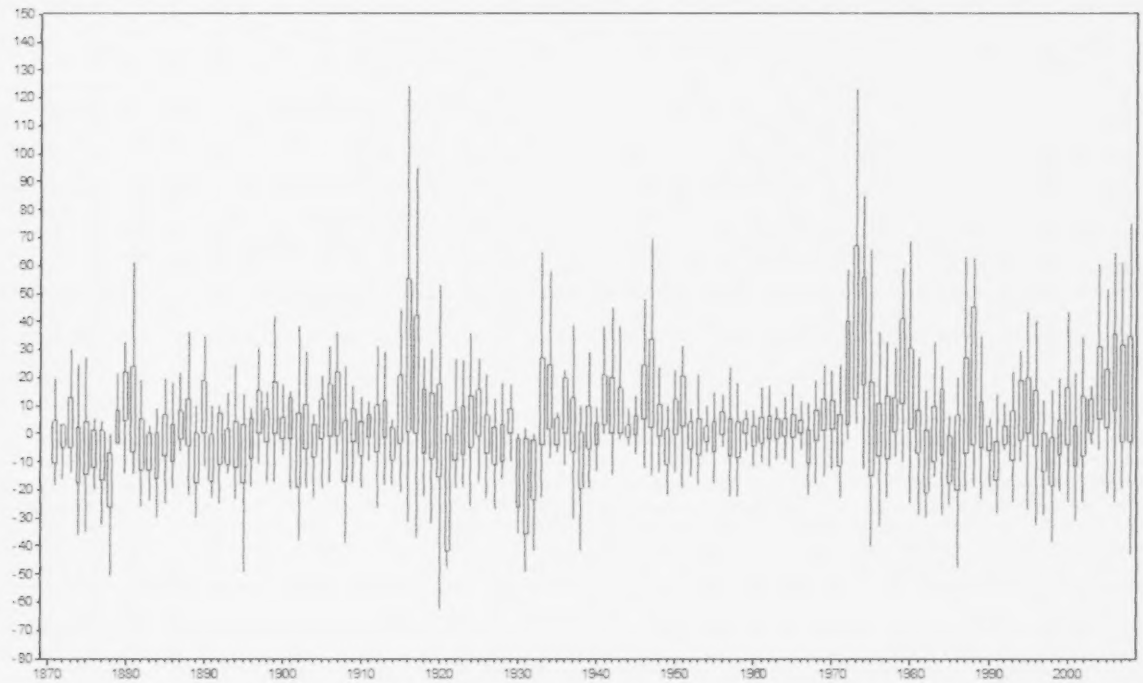
Source: Statistics Canada, author's calculations.

One way to illustrate the pattern seen in Chart 6 is to calculate growth rates for the long-run BCPI by decade. During particular decades—1910 to 1920, 1940 to 1950 and 1970 to 1980 (Table 7) —there is a rapid increase in commodity prices, while in the decade or two that follow, there is retrenchment or only minor growth. Once again, a sequence of periods that exert strong pressure followed by periods of relative calm prevails through time.

An alternative method of illustrating the pattern of growth followed by calm is to apply a moving average to growth rates. While this is not a sophisticated way to filter the time series, it is useful for demonstrating the on-again, off-again growth found across commodity types. Here, a nine-period central moving average of year-to-year changes in the sub-indexes is shown (Chart 9). The moving averages imply that, since 1900, Canada has been subject to four waves of commodity price increases. In the first half of the period, there is a period of accelerating commodity price growth, culminating with the First World War, before a period of retrenchment in the 1920s and 1930s. Another cycle starts thereafter and grows through the 1940s, before a period of low growth rates in the 1950s and 1960s. The 1970s usher in the third increase in commodity prices, followed by a period in the late 1980s and 1990s of weak growth. The fourth, and latest, wave occurs in the 2000s.

Chart 10
Box and whisker plots for the growth rates of the long-run Bank of Canada commodity price index, commodities by year

percent change



Source: Statistics Canada, author's calculations.

A third way to examine the on-again, off-again growth is to look at the distributions in price growth across commodities. Chart 10 shows box plots for the growth of the individual price series that go into the BCPI. The box plots are drawn so that the length of the box covers the 25th to the 75th percentile observations of the distribution. The whiskers extend to the upper and lower adjacent values. The upper adjacent value corresponds to the sum of the largest observation below the 75th percentile value plus 1.5 times the interquartile range. The lower adjacent value corresponds to the smallest observation above the 25th percentile value minus 1.5 times the interquartile range. Outliers, of which there are some extreme values, are not shown.

Chart 10 shows that when periods of growth occur, the entire distribution of price growth tends to increase. This does not mean that every commodity rises by the same amount, or that the position of a commodity in the distribution is fixed through time. Rather, the up-and-down fluctuations of the distributions suggest a more broadly based source of price changes during the periods of stronger price growth, rather than commodity-specific, or commodity-group-specific, changes.

Additionally, the spread of commodity-price movements, which in the box plots is represented by the length of the box and whiskers, increases during periods of stronger price growth and contracts during periods of slower price growth. In other words, commodity price changes exhibit greater variation during periods of more rapid increase.

Finally, periods of heightened price growth exhibit a degree of serial correlation, so that the periods of accelerated growth are not randomly dispersed. Instead, the distribution of growth rates increases for a number of years in a row, in periods such as the First World War or the 1970s, which are then followed by a number of years where the distribution is lower.

4.4.3 Commodity price shocks

The source of the dynamics in commodity-price movements is of considerable interest, and two competing hypotheses are presented. The first is that changes in monetary policy regime are responsible. The second stems from the study of commodity super cycles and suggests that demand- and supply-based changes are primarily responsible. Rather than argue for one or the other, this paper will simply note that there is support for both theories and that it is difficult to gain sufficient degrees of freedom to disentangle them.

4.4.3.1 Monetary policy shocks

The notion that changes in monetary policy correspond with rapid growth of commodity markets could be interpreted in three ways. The first is that the periods of accelerated commodity price growth reflect changes in the overall price level. In this case the real price of commodities, that is, the long-run BCPI deflated by an aggregate price index, should be fairly flat, and should not exhibit large changes around monetary regime changes. A second is that changes in monetary policy elicit relative price changes (Balke and Wynne 2003), and that commodity prices in particular are more sensitive (Clarke 1999). Under this hypothesis, the real price of commodities increases sharply around changes in monetary regime. A third possibility is that the relationship is spurious. Major changes in economic order could be derived from various societal pressures, and when shifts occur, they affect many aspects of an economy or society, including the relative price of commodities and monetary policy.

In the period between 1870 and 2015, there were 4 (possibly 5) major monetary policy regimes. The first is the period under the classical gold standard (1870 to the First World War), the second covers the inter-war period where nations attempted to re-establish the gold standard, the third is the Bretton-Woods period from the end of the Second World War until the early 1970s, and the fourth is the period of fiat currencies in place from the end of the Bretton Woods period until the present (see Bordo 1993, 2008).[5]

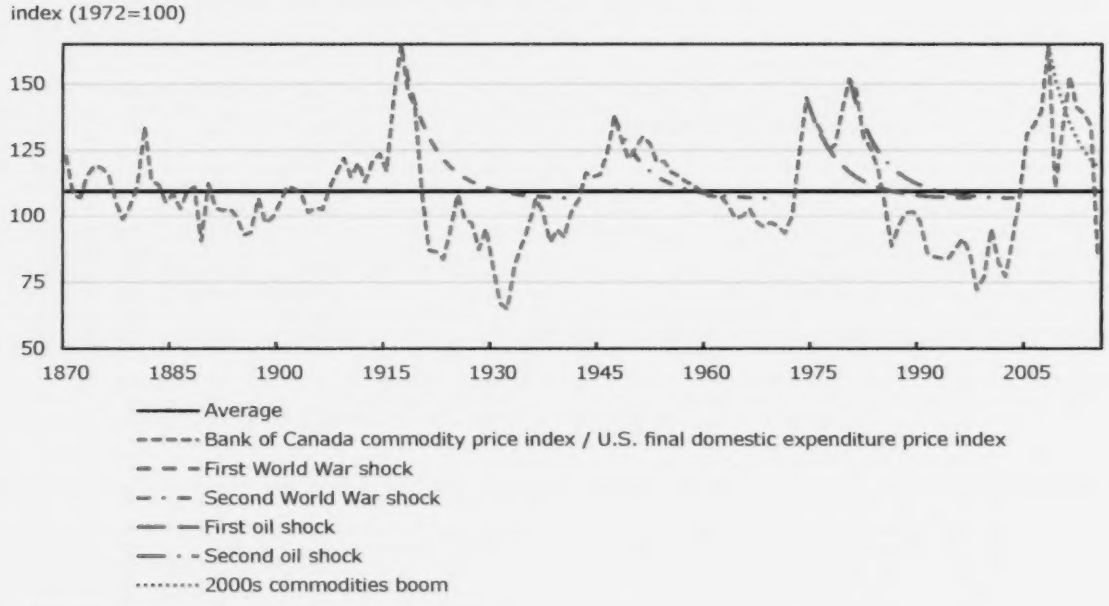
The possible fifth regime, which is less clear, could come from a transition to a multi-polar monetary system. In this respect, the emergence of Brazil, Russia, India and China (BRIC nations), and particularly of China, had the effect of greatly changing international monetary policy, and so could be interpreted to have initiated a period of monetary policy regime change (see for example *The Economist* 2005). Similarly, the adoption of the Euro in 1999 could be argued to have changed international monetary policy arrangements. These events moved the global economy towards a multi-polar monetary system (Dailami and Masson 2009), and may therefore represent a major shift in monetary policy, but unlike previous shifts since 1870, one that occurred outside of the United States.

To examine whether or not periods of more rapid commodity price increases are consistent with changes in the overall price level, the long-run BCPI is deflated by the U.S. final domestic expenditure (FDE) deflator (Chart 11). The U.S. FDE deflator is used because the prices in the long-run BCPI are in U.S. dollars. The long-run index shows that over the 145 years covered, commodity price inflation accelerates at around the same time that major changes in monetary policy regime. These accelerations also occur when the long-run BPCI is deflated using a U.S. final domestic expenditure price index[6] (Chart 11). The rapid increases in the real long-run BCPI around the First World War, the Second World War, the end of the Bretton Woods period, and over the 2000s provide strong evidence that commodity prices adjust more than the overall price

5. The four regimes are intended to outline major changes in monetary policy, but they are not exhaustive. For example, monetary policy since the end of the Bretton Woods period can be further divided into periods when different types of rules were attempted, such as the use of the Phillips curve or inflation targeting. The four regimes, however, do coincide with major changes in monetary stance that had global implications.
6. The deflation is derived by the author using multiple sources.

level. In other words, the deflated data do not support the notion that periods of accelerated commodity price change simply reflect periods of more rapidly rising overall price levels.

Chart 11
Long-run Bank of Canada commodity price index deflated by the U.S. final domestic expenditure price index



Source: Statistics Canada, author's calculations.

The deflated long-run BCPI shows periods of more rapid acceleration than the general price level during the periods when growth in the long-run BCPI accelerates. The periods of relative price increase are followed by (often longer) periods of decline towards the original relative price structure. The pattern of a rapid increase in relative commodity prices followed by a return to a more normal relative price structure resembles a time series in which periodic shocks perturb a system that then returns towards equilibrium. Chart 11 demonstrates this for the periods of relative commodity price decline following significant positive shocks.

A value for the "normal" relative price of commodities is estimated based on the long-run averages of all data points. An autoregressive, or AR(1), model, is estimated using the complete sample, and the projected path from the peak of each regime change back to the average is shown in Chart 11.[7] In the case of the 1970s transition, the path from the 1973 and 1979 peaks are shown. The estimated path to return to equilibrium fits well with the path of the relative price of commodities during its return towards equilibrium, except during the period covered by Bretton Woods after the Second World War. However, the simple AR(1) model is unable to match the overshooting that occurs in each period.

Nevertheless, the AR(1) model is compatible with a system where periodic shocks (in this case major changes to monetary policy regime) create a relative price change. That relative price

7. In the model, all coefficients are statistically significant at the 5% nominal level and have economically significant coefficient values. The model is parameterized as follows:
$\ln(BCPI_t / P_{fdet}) = 0.84 + 0.82 * \ln(BCPI_{t-1} / P_{fdet-1})$,
$R-2 = 0.67$,
$D-W = 1.65$.

change is then worked out of the system over a period of 9 to 11 years (roughly half a generation). This period is quite long, well in excess of more typical periods of adjustment associated with monetary shocks.

In summary, there are a number of periods when changes in monetary policy regime coincide with important changes in the relative price of commodities, and the behaviour of commodity prices relative to the U.S. FDE deflator could be interpreted to follow an autoregressive-model-type adjustment pattern. There is support for the hypothesis that factors beyond changes in the general price levels are important for commodity price growth and that changes in relative commodity prices may correspond with changes in monetary policy regime.

While there is support for the notion that major changes in monetary policy regime can influence the relative price of commodities, in the context of this paper, there are not sufficient degrees of freedom to disentangle the effect of monetary policy regime changes from the effect of historical events. Major changes affecting economic systems, such as the two world wars or the emergence of the Euro and BRIC nations, can cause significant change throughout economies. It may therefore be unsurprising that major relative price adjustments and changes in policy stance occur simultaneously. An inference problem thus arises, where it becomes difficult to identify whether the change in monetary policy regime was responsible for the change in relative commodity prices, or whether the changes in relative commodity prices and monetary policy regime changes are due to more general changes brought about by major historical events.

4.4.4 Super cycles

An alternative to the role of monetary policy is the presence of a cycle in the long-run real BCPI that has a multi-year duration. This type of "super cycle" has recently been described for particular prices (see, for example, Jacks 2013; Cuddington and Jerrett 2008; Jerrett and Cuddington 2008). Super cycles are said to occur as periods of increased demand (often argued to stem from mass industrialization or from urbanization) cause accelerated price growth that only returns to trend over decades because of constraints in the supply response (Jacks 2013; Erten and Ocampo 2013).

In the context of the long-run real BCPI, the two world wars coincided with periods of rapid, mass industrialization in North America, but also with a great destruction of production capacity in Europe and Asia. The role of mass industrialization in commodity demand in global markets is, therefore, unclear for the long-run real BCPI. The 1970s coincided with a broad-based commodity price increase, but, because of the role of the oil shocks, this is often characterized as a period of supply disruption and de-industrialization in developed economies.

During the 1870-to-2015 sample period, the two most significant periods of urbanization in the United States occurred early: in the late 1800s and early 1900s, and in the 1950s. However, these correspond to periods of decline or stagnation in the long-run real BCPI. The period from the mid-1990s to 2015 also represented a period of important urbanization, but one that stemmed from changes in the BRIC nations rather than in the United States.

Relative to historical events, the super-cycle hypothesis based on mass industrialization or urbanization is less consistent with known events. Nevertheless, super cycles are presented here for two reasons.

First, a number of periods of significant demand and supply changes coincide with periods of more rapid commodity price growth. War demand, supply disruption and the integration of the BRIC nations into the global economy in the 1990s and 2000s all represent periods when real economy influences, rather than monetary effects, may be responsible for the pattern of acceleration followed by calm found in the long-run real BCPI, even if their timing does not directly align with periods of urbanization or mass industrialization.

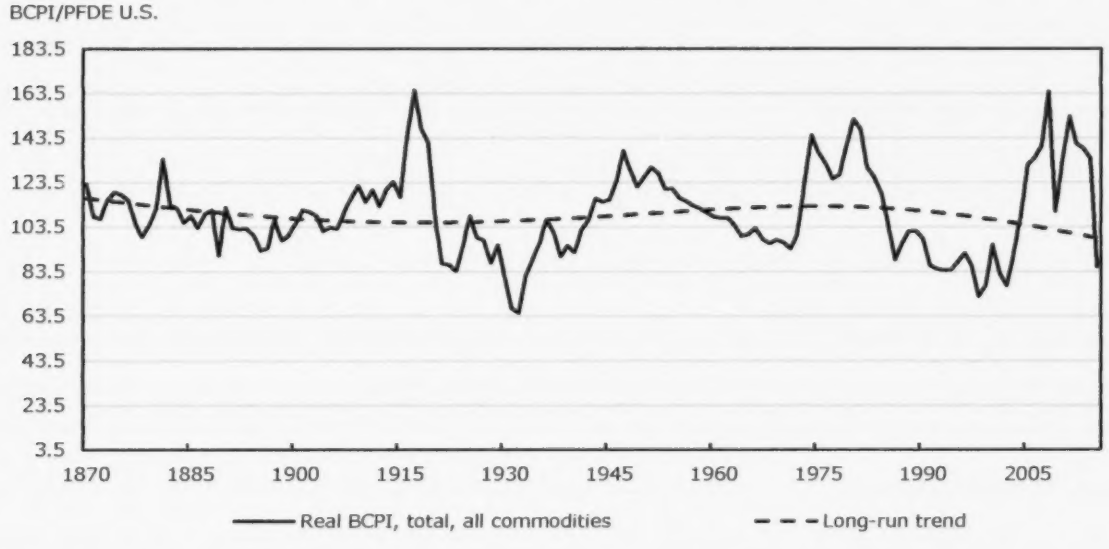
Second, the periodic acceleration found in the long-run real BCPI has a noteworthy degree of cyclicality. Beginning with the First World War, there is a period of accelerated commodity growth roughly every 30 to 35 years. So, while the sources may be different, there may also be a set of responses in economies that is stable across time and that affects economic performance for the following generation.

Super cycles are measured here using the asymmetric band-pass filter developed by Christiano and Fitzgerald (2003). This follows the practice of Jacks (2013) and Cuddington and Jerrett (2008). The band-pass filter is used to decompose the logarithm of a price series into a long-run trend, a super-cycle component spanning 20 to 70 years, and another component spanning less than 20 years, as follows:

$$\ln P \equiv \ln P^{Trend} + \ln P^{Supercycle} + \ln P^{Other}$$

The trend component is illustrated relative to the natural logarithm of the long-run real BCPI in Chart 12, while the deviation from the long-run trend and the super cycle are illustrated in Chart 13. The long-run trend is not required to be constant through time and is permitted to adjust as the low-frequency behaviour of the series evolves. In the case of the logarithm of the long-run real BCPI, the long-run trend first declines during the period of generally falling prices in the 1870s and 1880s, before turning positive until the late 1960s. It then declines modestly until the end of the sample period.

Chart 12
Long-run real Bank of Canada commodity price index and its trend



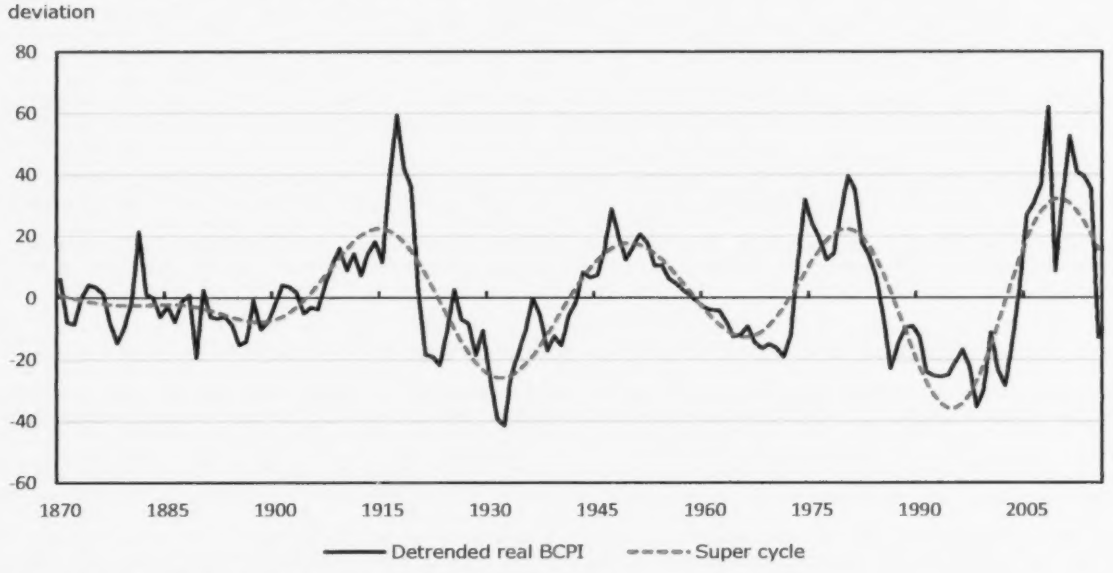
Notes: BCPI stands for Bank of Canada commodity price index. PFDE U.S. stands for U.S. final domestic expenditure price index.

Source: Statistics Canada, author's calculations based on CANSIM table 383-0027.

The deviation from the long-run trend and the super-cycle component follow a similar path, with the difference between the two representing other shorter-term deviations that reflect idiosyncratic shocks and business cycles. The super cycle in the long-run real BCPI has peaks in 1915, 1949, 1980 and 2009, with 34 years between the first two peaks, 31 years between the second two peaks and 29 years between the last two. The troughs occur in 1898, 1932, 1966 and 1995, with 34, 34 and 29 years, respectively, between them. On average, the cycles take an average of 15.5 years to move from a trough to a peak and 16.3 years to move from a peak to a trough.

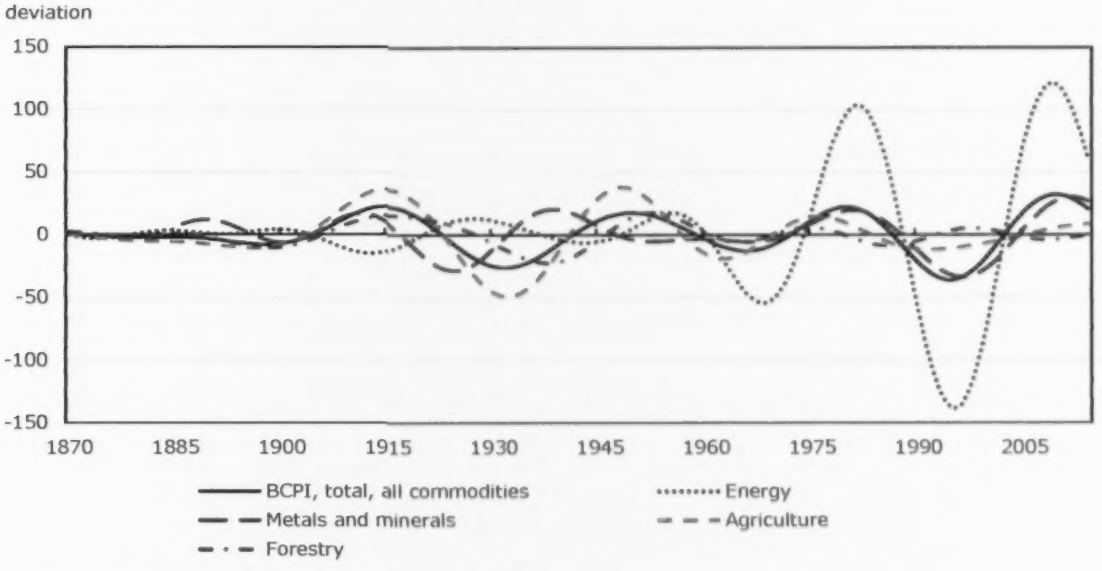
Across the cycles, 1950s is the mildest, while the trough that coincides with the commodity price weakness in the 1990s is the deepest. The highest peak is the final peak (2009), which has the greatest amplitude of all cycles in the sample.

Chart 13
Long-run real Bank of Canada commodity price index deviations from the trend and the super-cycle component



Note: BCPI stands for Bank of Canada commodity price index.
Source: Statistics Canada, authors' calculations.

Chart 14
Super-cycle components for the long-run real Bank of Canada commodity price index and its sub-indexes



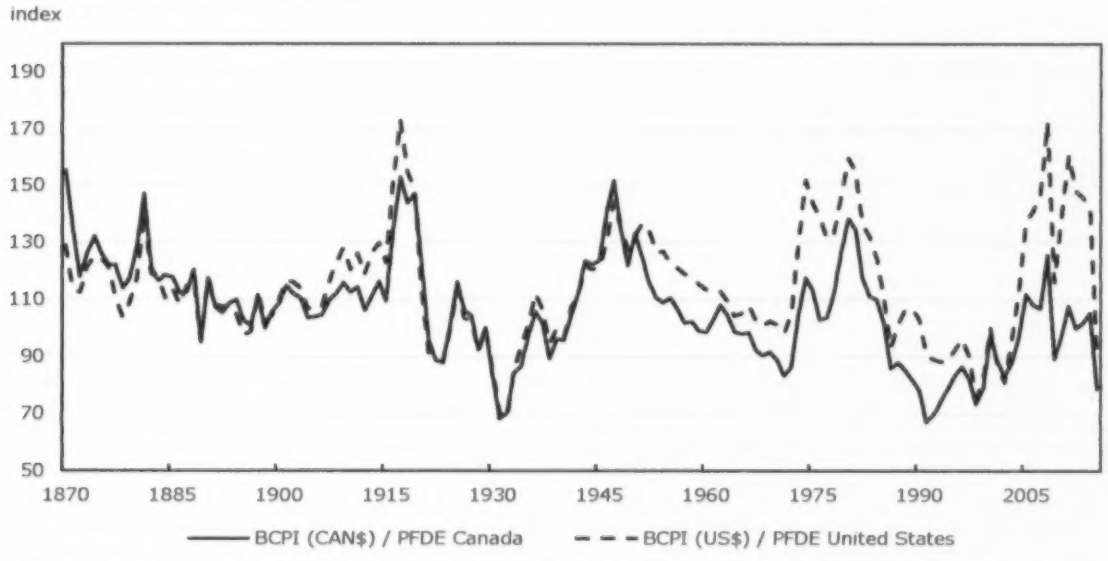
Note: BCPI stands for Bank of Canada commodity price index.
Source: Statistics Canada, author's calculations.

Across the sub-indexes of the long-run real BCPI, the super-cycle components display some synchronicity. The peaks and troughs of the super cycles for agriculture and forestry often occur around the same time, although their amplitudes can be quite different. The super cycles for metals and minerals occur around the same time as those for agriculture and forestry in the first and final cycles, but behave differently from the 1930s to the 1960s. The energy super cycle in the first half of the period is negatively correlated with those for the other sub-indexes, but all sub-indexes become positively correlated in the second half of the period. The change in behaviour coincides with an increase in the amplitude of the energy cycle.

4.4.5 Commodity price changes in Canada

The long-run BCPI measures price changes in U.S. dollars for commodities important for Canada. Therefore, it does not reflect price changes relevant to Canadian producers when the U.S.–Canada exchange rate changes. For most of the period in question, Canada has had an exchange rate with the United States that is at or near parity. However, during the last 40 years, in the post-Bretton Woods period, Canada had a floating exchange rate. This creates a divergence between the change in the price on world markets and the change in the price relevant to Canadian producers. To illustrate this point and the different behaviour of the post-Bretton Woods period, the long-run real BCPI is presented in terms of U.S. and Canadian dollars in Chart 15.

Chart 15
Long-run real Bank of Canada commmodity price index in U.S. and Canadian dollars



Notes: BCPI stands for Bank of Canada commodity price index. PFDE stands for final domestic expenditure price index.
Sources: Statistics Canada, author's calculations.

As Chart 15 illustrates, the change in relative commodity prices as measured by the long-run real BCPI is essentially the same in U.S. dollars and Canadian dollars between 1870 and 1970. This is a result of having an exchange rate regime that was, for the most part, fixed at parity with the U.S. dollar, or that remained within about 10 cents of parity during periods when it was floating. The post-Bretton Woods period, however, saw a depreciation of the exchange rate through the 1980s and 1990s to reach $0.636 in 2002, before climbing above parity in the late 2000s.

These exchange-rate movements had the effect of dampening differences in commodity price growth across the years, consistent with the expectation that a floating exchange rate acts as a shock absorber for foreign shocks. As a result, real commodity price changes in Canadian dollar terms are more muted in Canada than in the United States under the current exchange-rate regime. Consequently, the force of commodity price changes in global markets does not exert as much short-run relative price pressure in Canada as it does in the United States.

5 Conclusion

Historical estimates for the BCPI and its sub-indexes have been produced for the period from 1870 to 1971 to link with the current BCPI. The estimated values reflect important historical events, from major economic shocks to the emergence of oil production and the electrification of the production process. Therefore, they contain information relevant for understanding processes related to emerging commodity production and structural change.

They also contain significant information about the timing of pressure exerted by commodity prices in Canada. The long-run BCPI, which links historical estimates to the BCPI, correlates with export prices and wholesale prices, suggesting that the magnitude and timing of events captured by the long-run index are appropriate. However, because the BCPI is chain-weighted, it more accurately measures growth rates than historical fixed-weight sources.

The long-run BCPI and its sub-indexes have growth-rate distributions characterized by skewness and kurtosis relative to a normal distribution. They are, in other words, subject to large innovations, with positive innovations being relatively larger. As a result, measures of average growth, variance, correlation, covariance and regression estimators, such as ordinary least squares, are biased because of the presence of these influential observations. The extent to which this may create problems for analysis and modelling depends on the use to which the data are put.

The long-run BCPI, its sub-indexes and the prices used to construct them also show a process of short periods of pressure, followed by periods of calm. This super-cycle-type pattern is most pronounced in the real long-run BCPI after the end of the classical gold standard at the outbreak of the First World War and often coincides with major changes in monetary regime.

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